Idaho National Engineering and Environmental Laboratory

# INTEROFFICE MEMORANDUM

**Date:** October 30, 2002

**To:** V. L. Jacobson MS 3670 6-3763

**From:** R. R. Kimmitt MS 3670 6-5158

**Subject:** TANK WM-182 CLEANING EFFECTIVENESS

**References:**
(a) DOE/ID-10802, *Idaho Hazardous, Waste Management Act/Resource Conservation and Recovery Act Closure Plan for Idaho Nuclear Technology and Engineering Center Tanks WM-182 and WM-183*, November 2001
(b) DOE/ID-10777, *Idaho Nuclear Technology and Engineering Center Tank Farm Facility Residuals - Waste -Incidental-to-Reprocessing Determination Report*
(c) EDF-1920 Revision 4, *Validation of the Radionuclide Mass Balanced Used in the INTEC SBW WIR Determination Report*, August 29, 2002

Throughout the summer of 2002, vessel WM-182 at INTEC was cleaned as part of a State-approved closure plan. Cleaning operations took place on six separate days. The primary goal of the cleaning process was to remove radioactivity and chemical contaminants from the tank. Once the maximum practical amount of radioactivity had been removed (and pumped to nearby tank WM-187), the remaining contents would be grouted in place within WM-187. Mock-up tests have shown that the grouting process also moves much of the remaining liquids and solids to the ejector pump so they can be removed. So the grouting method helps clean the tank (reference a).

As part of the documentation for a "Waste Incidental to Reprocessing" (WIR) determination from DOE, an initial prediction of the cleaning process performance was made. To do this, the cleaning process was modeled as a continuously stirred tank with clean water entering through spray nozzles and dirty water leaving through the steam ejector (reference b). It was estimated that the bulk of the radioactivity could be removed by spraying about 75,000 gallons of clean water into the tank. In practice, it was not expected that stirred tank conditions could be maintained. The influent flow rate was about 75 gpm while the ejector could only pump about 50 gpm. The flow of wash water was periodically stopped to keep the fluid level from continuously rising and dampening the impact of the wash water streams. With a low fluid level, the maximum amount of mixing could be obtained from the wash water as it was sprayed into the tank. Complete mixing was also unlikely because of the tank configuration. The tank is 50 feet in diameter, and, during the cleaning process, the fluid level was kept between 1 and 6 inches. Complete mixing in a large shallow tank was expected to be difficult to achieve.

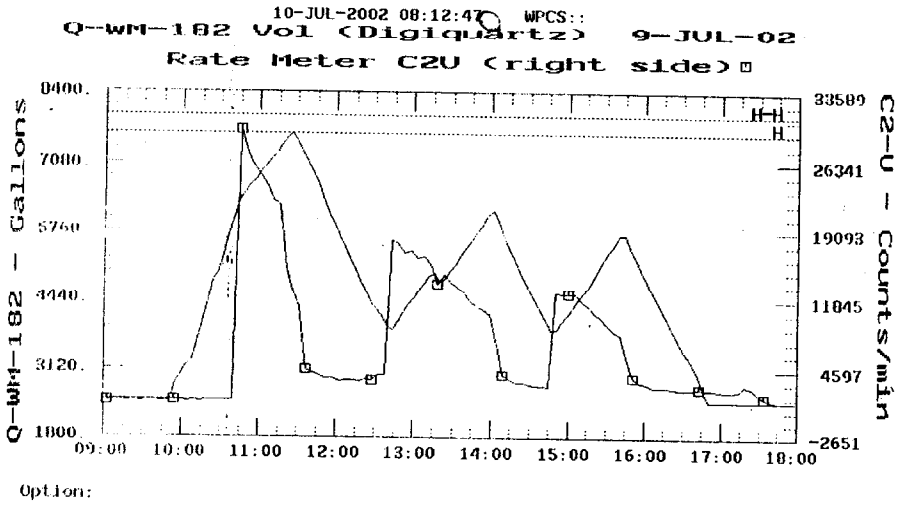
Even with the limitations inherent in the cleaning methods, it is estimated that about 93% of the total radioactivity in the tank was removed. As discussed below, this value is based on the following information: (1) analyses of samples of the tank contents before and after cleaning, (2) visual observations of the tank bottom and sides before, during, and after cleaning. The rate of removal of radioactivity showed an exponential decrease, as would be expected from a continuously stirred tank. The actual data from tank cleaning showed that nearly complete mixing was achieved, although there

was a practical limit to the amount of solids removed. It is estimated that about 1,800 curies of radioactivity remained in the tank at the end of the washing process. A significant fraction of that radioactivity will be removed early in the tank grouting process.

## Data Collection

Radioactivity being pumped from tank WM-187 was monitored in the discharge piping in valve box C-2. The detector was an unshielded GM counter mounted near the pipe. Output from the counter was recorded at counts per minute at periodic time intervals. No measurement or estimate of detector efficiency is available. The count rate data were provided to project personnel in the form of charts. Figure 1 is an example.

Figure 1. Discharge Pipe Radiation Readings




No discharge volume flow rate data are available. It has been assumed that the ejector operated continuously at 50 gpm during each cleaning session. Flow was periodically interrupted to the wash ball and wash nozzles to prevent the tank fluid level from rising above the desired range.

## Data Analysis

To determine how the radioactivity content of tank WM-182 was decreasing, it was necessary to estimate the activity concentration of material being pumped from the vessel. The count rate was typically noted at10-15 minute intervals. From these values and the assumed flow rate, a "concentration" term was calculated and plotted against cumulative volume of liquid pumped from the vessel. It was necessary to subtract a "background" level from the count rate information. Typically, background was

assumed to be the starting count rate on each day of pumping operations. Table 1 and Figure 2 show the calculations and resulting curve.

Table 1. Count Rate Calculations

| Date | Hours | Minutes | Cumulative Gallons Pumped | Counts per Minute (adjusted for background) | CPM/Gallon |
|---|---|---|---|---|---|
| 6/27/2002 | 16 | 20 | 0 | - | N/A |
| | 17 | 0 | 2000 | - | - |
| | 17 | 15 | 2750 | 8,232 | 11 |
| | 17 | 30 | 3500 | 5,051 | 7 |
| | 17 | 45 | 4250 | 3,750 | 5 |
| | 18 | 0 | 5000 | 3,326 | 4 |
| | 18 | 15 | 5750 | 16,185 | 22 |
| | 18 | 30 | 6500 | 21,969 | 29 |
| | 18 | 45 | 7250 | 13,293 | 18 |
| | 19 | 0 | 8000 | 723 | 1 |
| | 19 | 15 | 8750 | - | - |
| | | | | | |
| 7/9/2002 | 9 | 50 | 8750 | - | N/A |
| | 10 | 15 | 10000 | 8,698 | 7 |
| | 10 | 30 | 10750 | 15,221 | 20 |
| | 10 | 45 | 11500 | 28,267 | 38 |
| | 11 | 0 | 12250 | 23,919 | 32 |
| | 11 | 15 | 13000 | 20,874 | 28 |
| | 11 | 30 | 13750 | 11,451 | 15 |
| | 11 | 45 | 14500 | 3,623 | 5 |
| | 12 | 0 | 15250 | 2,900 | 4 |
| | 12 | 15 | 16000 | 2,610 | 3 |
| | 12 | 30 | 16750 | 3,190 | 4 |
| | 12 | 45 | 17500 | 17,396 | 23 |
| | 13 | 0 | 18250 | 16,361 | 22 |
| | 13 | 15 | 19000 | 14,496 | 19 |
| | 13 | 30 | 19750 | 13,046 | 17 |
| | 13 | 45 | 20500 | 11,161 | 15 |
| | 14 | 0 | 21250 | 9,713 | 13 |
| | 14 | 15 | 22000 | 2,900 | 4 |
| | 14 | 30 | 22750 | 2,175 | 3 |
| | 14 | 45 | 23500 | 2,030 | 3 |
| | 15 | 0 | 24250 | 11,596 | 15 |
| | 15 | 15 | 25000 | 10,438 | 14 |
| | 15 | 30 | 25750 | 8,118 | 11 |

Table 1. Count Rate Calculations (Continued)

| Date | Hours | Minutes | Cumulative Gallons Pumped | Counts per Minute (adjusted for background) | CPM/Gallon |
|---|---|---|---|---|---|
| 7/9/02 | 15 | 45 | 26500 | 4,928 | 7 |
| | 16 | 0 | 27250 | 1,885 | 3 |
| | 16 | 15 | 28000 | 1,595 | 2 |
| | 16 | 30 | 28750 | 1,450 | 2 |
| | 16 | 45 | 29500 | 1,305 | 2 |
| | | | | | |
| 7/22/2002 | 9 | 45 | 29500 | | |
| | 10 | 0 | 30250 | - | - |
| | 10 | 15 | 31000 | - | - |
| | 11 | 15 | 34000 | 8,976.20 | 12 |
| | 11 | 30 | 34750 | 5,553.00 | 7 |
| | 11 | 45 | 35000 | 3,147.40 | 4 |
| | 12 | 0 | 36250 | 1,526.90 | 2 |
| | 12 | 15 | 37000 | 1,295.40 | 2 |
| | 12 | 30 | 37750 | 6,709.50 | 9 |
| | 12 | 45 | 38500 | 6,431.70 | 8 |
| | 13 | 15 | 40000 | 4,719.60 | 6 |
| | 13 | 30 | 40750 | 1,943.60 | 3 |
| | 13 | 45 | 41500 | 1,341.70 | 2 |
| | 14 | 0 | 42250 | 4,765.90 | 6 |
| | 14 | 15 | 43000 | 3,932.50 | 5 |
| | 14 | 30 | 43750 | 3,608.40 | 5 |
| | 14 | 45 | 44500 | 2,638.10 | 4 |
| | 15 | 0 | 45250 | 1,295.40 | 2 |
| | 15 | 15 | 46000 | 2,452.90 | 3 |
| | 15 | 30 | 46750 | 3,008.50 | 4 |
| | 15 | 45 | 47500 | 1,388.00 | 2 |
| | 16 | 0 | 48250 | 972.30 | 1 |
| | 16 | 15 | 49000 | 833.40 | 1 |
| | 16 | 22 | 49350 | 787.10 | 2 |
| | | | | | |
| 8/15/02 | 10 | 25 | 49350 | | |
| | 10 | 30 | 49600 | - | - |
| | 10 | 52 | 507000 | 840.00 | 1 |
| | 10 | 55 | 50850 | 3,640.00 | 24 |
| | 11 | 0 | 51100 | 3,240.00 | 13 |
| | 11 | 7 | 51450 | 2,540.00 | 7 |

Table 1. Count Rate Calculations (Continued)

| Date | Hours | Minutes | Cumulative Gallons Pumped | Counts per Minute (adjusted for background) | CPM/Gallon |
|---|---|---|---|---|---|
| 8/15/02 | 13 | 52 | 51450 | - | - |
| | 14 | 0 | 51850 | 4,440.00 | 11 |
| | 14 | 10 | 52350 | 5,340.00 | 11 |
| | 14 | 20 | 52850 | 4,380.00 | 9 |
| | 14 | 30 | 53350 | 3,880.00 | 8 |
| | 14 | 40 | 53850 | 3,060.00 | 6 |
| | 14 | 45 | 54100 | 2,880.00 | 12 |
| | | | | | |
| 8/21/02 | 13 | 35 | 54100 | 707.20 | - |
| | 13 | 45 | 54600 | 353.60 | 1 |
| | 13 | 55 | 55100 | 299.20 | 1 |
| | 14 | 5 | 55600 | 353.60 | 1 |
| | 14 | 15 | 56100 | 326.40 | 1 |
| | 14 | 25 | 56600 | 380.80 | 1 |
| | 14 | 35 | 57100 | 2,801.60 | 6 |
| | 14 | 45 | 57600 | 5,222.40 | 10 |
| | 14 | 55 | 38100 | 3,916.80 | 8 |
| | 15 | 0 | 58350 | 2,393.60 | 10 |
| | 15 | 10 | 58850 | 1,713.60 | 3 |
| | 15 | 20 | 59350 | 707.20 | 1 |
| | 15 | 30 | 59850 | 462.40 | 1 |
| | 15 | 40 | 60350 | 353.60 | 1 |
| | 15 | 50 | 60850 | 217.60 | 0 |
| | 16 | 0 | 31650 | - | - |
| | | | | | |
| 8/26/2002 | 9 | 50 | 61350 | - | - |
| | 10 | 0 | 61850 | 1,478.40 | 3 |
| | 10 | 10 | 62350 | 963.20 | 2 |
| | 10 | 30 | 63350 | 1,747.20 | 2 |
| | 10 | 45 | 34100 | 828.80 | 1 |
| | 11 | 0 | 64850 | 560.00 | 1 |
| | 11 | 15 | 65600 | 470.40 | 1 |
| | 11 | 30 | 66350 | 2,732.80 | 4 |
| | 11 | 45 | 67100 | 3,382.40 | 5 |
| | 12 | 0 | 67850 | 1,792.00 | 2 |
| | 12 | 15 | 668600 | 716.80 | 1 |
| | 12 | 30 | 69350 | 604.80 | 1 |

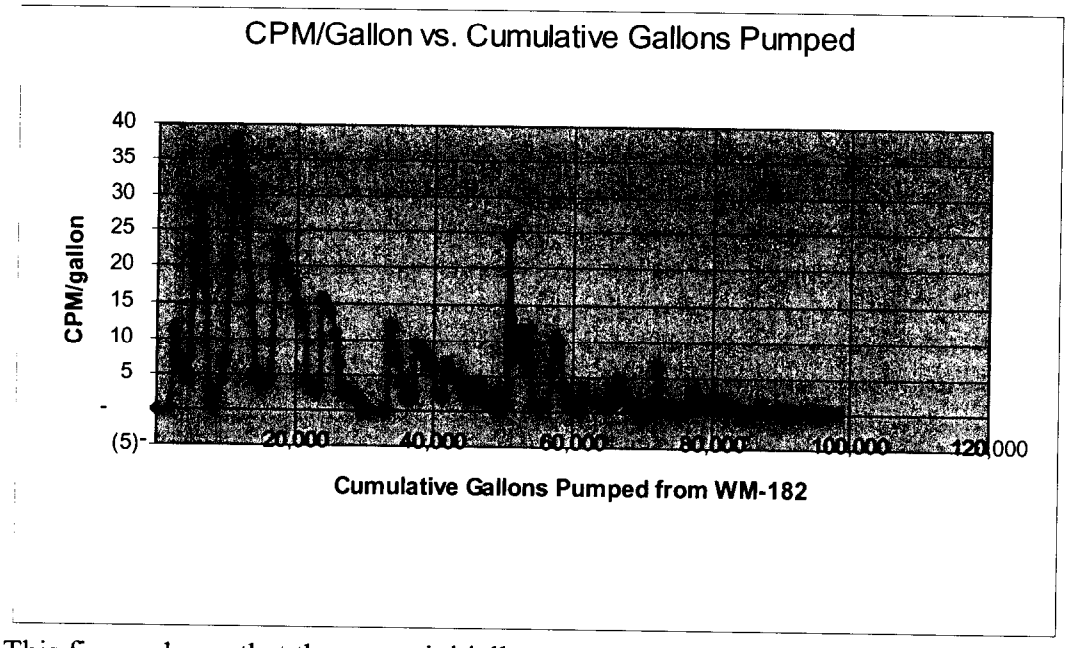
Table 1. Count Rate Calculations (Continued)

| Date | Hours | Minutes | Cumulative Gallons Pumped | Counts per Minute (adjusted for background) | CPM/Gallon |
|---|---|---|---|---|---|
| 8/26/2002 | 12 | 45 | 70100 | 582.40 | 1 |
| | 13 | 0 | 70850 | 179.20 | 0 |
| | 13 | 15 | 71600 | 67.20 | 0 |
| | 13 | 25 | 72100 | 44.81 | 0 |
| | | | | | |
| 9/4/02 | 12 | 40 | 72100 | - | - |
| | 12 | 45 | 72350 | 1,548.00 | 6 |
| | 13 | 0 | 73100 | 492.00 | 1 |
| | 13 | 15 | 73850 | 420.00 | 1 |
| | 13 | 30 | 74600 | 276.00 | 0 |
| | 13 | 45 | 75350 | 144.00 | 0 |
| | 14 | 0 | 76100 | 240.00 | 0 |
| | 14 | 15 | 76850 | 624.00 | 1 |
| | 14 | 30 | 77600 | 1,992.00 | 3 |
| | 14 | 45 | 78350 | 876.00 | 1 |
| | 15 | 0 | 79100 | 1,320.00 | 2 |
| | 15 | 15 | 79850 | 360.00 | 0 |
| | 15 | 30 | 80600 | 636.00 | 1 |
| | 15 | 45 | 81350 | 600.00 | 1 |
| | 16 | 0 | 82100 | 1,356.00 | 2 |
| | 16 | 15 | 82850 | 696.00 | 1 |
| | 16 | 30 | 83600 | 720.00 | 1 |
| | 16 | 45 | 84350 | 228.00 | 0 |
| | 17 | 0 | 85100 | 144.00 | 0 |
| | 17 | 15 | 85850 | 96.00 | 0 |
| | | | | | |
| 9/9/02 | 10 | 15 | 85850 | - | - |
| | 10 | 30 | 86600 | - | - |
| | 10 | 45 | 87350 | 1,110.220 | 1 |
| | 11 | 0 | 88100 | 138.90 | 0 |
| | 11 | 15 | 88850 | - | - |
| | 11 | 30 | 89600 | 416.70 | 1 |
| | 11 | 45 | 90350 | - | - |
| | 12 | 0 | 91100 | - | - |
| | 12 | 15 | 91850 | 138.90 | 0 |
| | 12 | 30 | 95600 | 46.30 | 0 |
| | 12 | 45 | 93350 | - | - |

Table 1. Count Rate Calculations (Continued)

| Date | Hours | Minutes | Cumulative Gallons Pumped | Counts per Minute (adjusted for background) | CPM/Gallon |
|---|---|---|---|---|---|
| 9/9/2002 | 13 | 0 | 94100 | - | - |
| | 13 | 15 | 94850 | - | - |
| | 13 | 30 | 95600 | - | - |
| | 13 | 45 | 96350 | - | - |
| | 14 | 0 | 97100 | 138.90 | 0 |
| | 14 | 15 | 97850 | 46.30 | 0 |
| | 14 | 30 | 98600 | - | - |

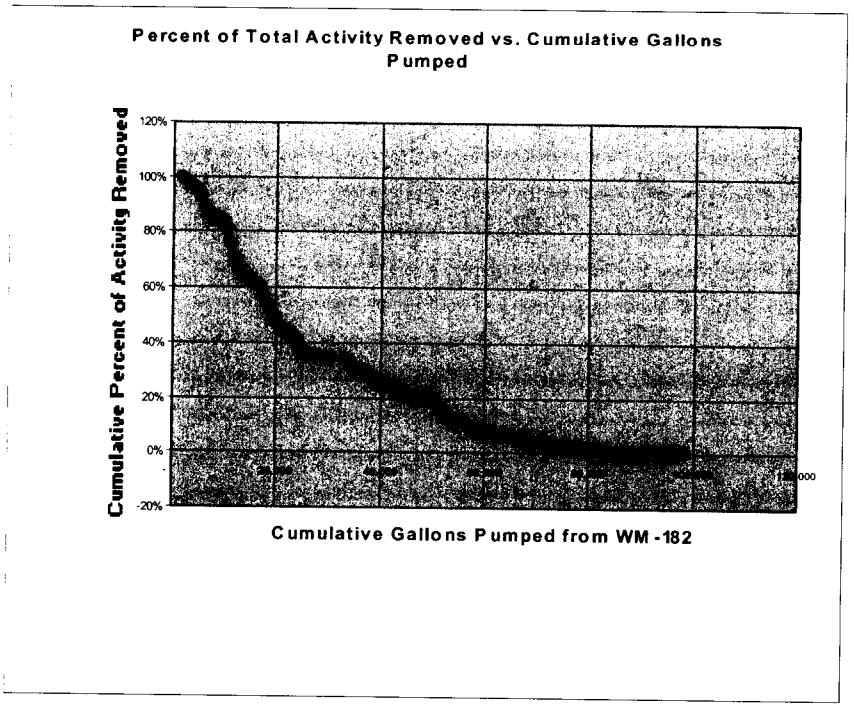
Figure 2. Activity Concentration Curve




This figure shows that there was initially a great deal of variability in the activity per unit volume of water pumped. Drops occurred when the wash water was shut off, and the suspended solids quickly settled to the bottom of the tank. The ejector could not efficiently pick up the settled solids. Once the wash water flow was restarted, the solids were re-suspended and pumped from the vessel. At first, only the wash ball was used, and it effectively stirred the solids. However, after 30,000 gallons had been pumped, this device became far less effective. At 50,000 gallons cumulative volume pumped, two directional nozzles were substituted for the wash ball. Solids removal efficiency increased immediately, but eventually tapered off again. By the time 98,000 gallons of water had been pumped, essentially no additional radioactivity was being removed with the wash water.

The total area under this curve represents the total amount of radioactivity removed from tank. The area was determined by numerical integration. So a general radioactivity reduction curve can be drawn. See Figure 3.

Figure 3. Reduction in Tank Radioactivity




To this point, the actual amount of radioactivity removed from the tank has not been estimated. The starting radioactivity content estimate is provided in EDF-1920 (reference c). The activity in the liquid is about 13,800 Curies (as of June, 2002), and the activity in the solids is about 14,000 Curies (as of June, 2002).

For the purpose of this evaluation, it has been assumed that the specific activity concentration in the solids does not change during washing. In other words, a gram of solids at the end of the washing process contained as much activity as a gram of solids at the beginning of the operation. On the other hand, the activity concentration in the liquid would be expected to decrease during cleaning because the contaminated water was blended with a relatively large volume of clean water. Figure 3 represents an exponential curve typical of a continuously stirred vessel, so the final activity associated with the water in the tank can be estimated as:

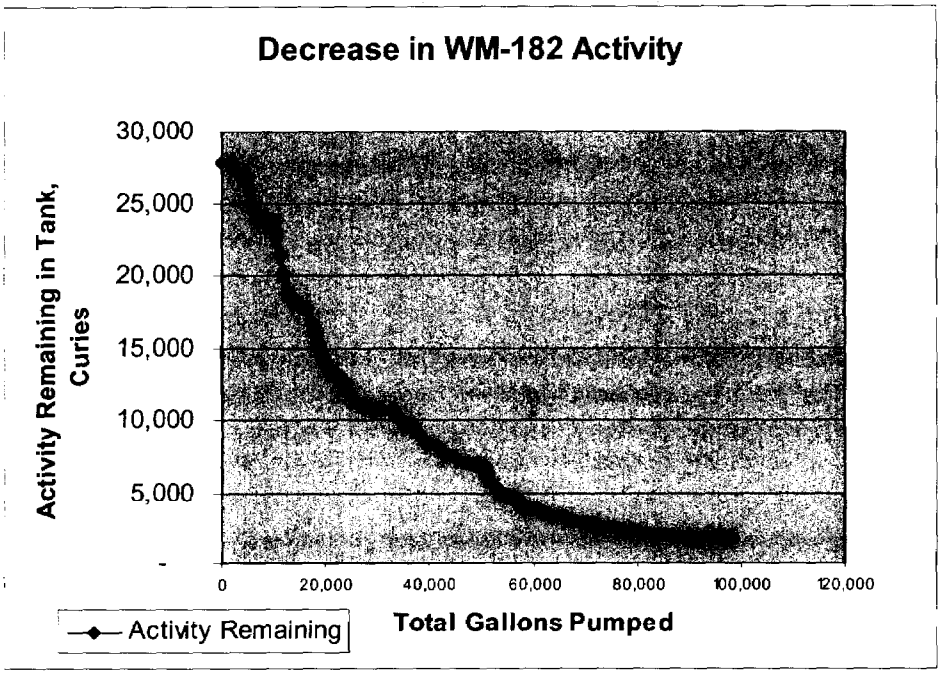
$$N = 15{,}000e^{-F/V}$$

Where: N = activity after F gallons of water have been pumped out
F = volume of water pumped out
V = nominal volume of water maintained in the tank = 7200 gal.

After 98,000 gallons of water had been pumped, the activity in the water phase should be less than 1 curie. In practice, since mixing was probably not complete, a final liquid activity value of 50 Curies has been assumed.

To estimate the activity associated with the solids, it was necessary to estimate the beginning and ending quantities of solids in the tank. Before cleaning started, samples and video tape inspections result in an estimate of 1,200 gallons of settled solids. This is 4-inches of sludge comprised of about ¼ solids by volume. At the end of the cleaning operation, the sludge layer was about ½ inch total, with about ¼ of that being suspended solids. Since the solids volume decrease by 7/8, it is expected that the solids activity was also reduced by 7/8. The total solids activity remaining at the end of cleaning is estimated to be about 1,750 Curies. So the total remaining in the vessel after cleaning is about 1,800 Curies. This means that 26,000 Curies of activity were removed from tank WM-182 during the washing operation. Applying these beginning and ending points for total activity to Figure 3 gives the curve in Figure 4, which relates gallons pumped with activity remaining in the tank.

Figure 4. Activity remaining as a function of water pumped from WM-182

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